so-called Dakota formation of the Black Hills belongs to the Lower Cretaceous series. This conclusion, together with the observations which led up to it, he published in the JOURNAL OF GEOLOGY in the following year. Since that time the work of investigation has been greatly extended through the efforts of Professor Ward and his co-laborers, with the result that his former conclusion is now fully substantiated.

New fossil localities were found, and many new species were collected. Of the cycads, one hundred and twenty-six trunks and fragments were examined. These were collected from two general although widely separated areas. The collection contains twenty-one species, all of which are new to science. Fossil forests are mentioned as occurring at the same horizon.

Professor Jenney makes a report on the Hay Creek region, in which he finds: a marine Jura characterized by an abundant invertebrate fauna; a later Jura resting unconformably upon the former, and characterized by saurian bones and fossil wood; above this the Lower Cretaceous, which he subdivides as follows: (1) the Hay Creek formation; (2) the Barrett shales; (3) the Oak Creek beds. The series is characterized by an abundant flora which contains no cycads.

The flora of the region is described by Professor Fontaine, who finds a number of species common to the Potomac formation, and a few common to the Kootenai. This suggests a closer relation with the eastern flora, but Mr. Ward thinks that this may not be the actual condition, as the Kootenai flora has not been as thoroughly investigated as the Potomac.

A few outcrops of the "Atlantasaurus beds" are reported as occurring on the eastern flank of the Black Hills. These consist of clays representing a thickness of about fifty feet and containing bones of saurians. The beds are thought to have been laid down in the depressions of the eroded surface of the marine Jura. W. N. LOGAN.

The Geology and Physical Geography of Jamaica: Study of a Type of Antillean Development. By ROBERT T. HILL. Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. XXXIV, 1899. pp. 256, 41 plates.

The general scope of this volume, which is an important addition to the work which the author has heretofore done on Antillean geology,

is indicated by the title of the several parts of the volume. These are as follows: Part I, Geography and Physiography; Part II, The Geologic Structure and Sequence; Part III, Paleontology of the Jamaican Sequence; Part IV, Relations of the Jamaican Formations to those of Adjacent Regions; Part VI, Changes of Physiography in Tropical America bearing upon the History of the West Indian Islands; Part VII, Appendices (1) Additional Note on the Geology of Porto Rico and Santiago de Cuba, and (2) Some Cretaceous and Eocene Corals of Jamaica (by T. Wayland Vaughan).

Geography.— Geographically the island is described as follows: There is a central mountain axis in the eastern third of the island, the highest point of which is between 7000 and 8000 feet above sea level. About this mountain axis, with its chief extension to the west, is a plateau ranging from 1000 or 1200 feet, to 3000 feet. The plateau is really a gentle arch, and its greatest elevation is in the central part of the island. The plateau terminates abruptly by steep slopes known as the "back coast border." The margins of the back coast border are irregular, the result of valley excavation. The plateau is chiefly of limestone, and its interior topography is largely the result of solution and interior drainage. The plateau contains many remarkable basins developed in this way. Some of them have no outlets, while others have recently been tapped by valleys working in from the margins of the plateau. The margins of the plateau are extensively terraced. On the east side of Montego Bay there are at least six terraces, and while the number elsewhere is fewer, some of them are at levels considerably above those shown at Montego Bay, so that the total number is more than six. The terraces are much interrupted by erosion, the oldest being least distinct, and most discontinuous. The highest occurs at elevations of 1800 or 2000 feet, an altitude quite above the top of the back coast border in some parts of the island. The second highest terrace occurs at an elevation of about 1500 feet, the next at 1000 feet, and others at 650, 300, and 200 feet respectively. The upper terraces appear to have been carved out of the limestone during the period of emergence which followed the deposition of the limestone. Those below 700 feet appear to have been carved in a later period of elevation, following a period of submergence, after the higher terraces were made. The terraces "have all been cut out of the land by gradational processes (base leveling and marine erosion) and represent pausation stages in two long periods of elevation" (p. 33).

If the back coast border of the plateau were continued seaward, the borders of the island would lie much beyond the present shore line, and from this and other phenomena it is inferred that the former extension of the island was considerably greater than the present. There are terraces on the submerged slopes of the island similar to those above the water, which are in harmony with this view.

Bordering the plateau below the back coast border there is a coastal plain which is nearly continuous. In some places it is narrow, and in others it reaches far back into the island. The coastal plain is made up of three sorts of formations, elevated reefs, sea margin débris, and land alluvium. The coastal plain is more or less terraced by old wave-cut terraces, which have since been submerged and are now veneered with later deposits. The highest is about 150 feet above sea level. Elevated reefs occur at three levels, 60, 25, and 15 feet or less, respectively, above sea level.

The streams of the island belong to two types: (1) the autogenous type, with the peculiarities which go with changes of level; and (2) the interior streams which drain into limestone sinks. In addition to these two types, there is a combination type which results from the capture of the interior drainage by streams which flow seaward.

A topographic map with 250-foot contours and a geologic map accompany the volume, and help to make the geography and geology clear.

Geology.—The central mountain axis of the island is made up of rocks known as the Blue Mountain series. This series is made up chiefly of "loose or slightly indurated beds of gravel, clay, bowlders, and tuffs, with exceptional beds or bosses of hard indurated limestones and yellow clay. The rocks are usually of dark color . . . . in strong contrast to the glaringly light colors which characterize the succeeding formations of the oceanic and coastal series. The material, with the exception of occasional limestone beds and a few outcrops of clay marls, can be traced to igneous rocks; it was first volcanic ejecta and subsequently and successively underwent various degrees of attrition and sedimentation" . . . . (p. 41).

This Blue Mountain series constitutes the surface formation of all parts of the island which rise above 3000 feet. From exposures at lower levels where erosion has removed the overlying strata, it is known that the same series has extensive development beneath the younger formations, and from the known exposures the series is believed to

underlie most of the island. The beds of the Blue Mountain series are much deformed. Since a continuous exposure of the total series is nowhere found, exact measures of thickness have not been obtained, but it is stated that the thickness probably exceeds 5000 feet.

The Blue Mountain series is made up of Upper Cretaceous and Lower Eocene beds. There seems at this point to be a little confusion in the classification, since the Richmond formation, which appears to be the upper part of the Blue Mountain series, is classed as Eocene at some points (geological map), but as Upper Cretaceous at others (p. 143). The Blue Mountain series is exposed in the central and western parts of the island at levels which are below the mountains of the east. In these localities, erosion has removed the overlying beds.

The Blue Mountain series is overlaid by the Cambridge formation, a formation not extensively exposed. Where it appears, it skirts the older series. It is made up of clays, marls, and yellow limestones, and occupies a transitional position between the older series, the material of which was derived from land formations, and the next succeeding formation, the material of which is limestone, and therefore of oceanic origin. The Cambridge formation is classified as late Eocene.

The Cambridge formation is followed in stratigraphic order by an extensive formation of White Limestone, the principal formation of the plateau. It has by far the widest surface development of any formation on the island. It covers the whole of the island between the top of the plateau (3000 feet) and the coastal plain, and underlies some portions of the latter. In the western part of the island it completely covers (or once did) the Blue Mountain series. The beds of limestone are often considerably disturbed. The formation is assigned a deep water origin, since it contains neither reef corals nor littoral shells. Its fossils are mainly microscopic, and it is referred to the earlier part of the Oligocene period.

The formations of the island younger than the White Limestone belong to the coastal series, and were made after great changes had affected the island. These coastal formations are made up of four sorts of rock: (1) marine beds, (2) alluvium, (3) elevated coral reefs, and (4) littoral deposits.

The oldest of these formations is known as the Bowden formation, the age of which seems to be in some doubt. It is regarded as either

late Oligocene or Miocene. The formation was deposited after a subsidence which followed the uplift and extensive erosion of the White Limestone. The break between it and the White Limestone is, therefore, a great one, and on general grounds it would seem more in accord with modern classification to make the break between these two formations the division between the Oligocene and Miocene than to place it in the Oligocene. The Bowden formation has a thickness of something like 250 feet. Its outcrop consists of a fringe around the older plateau region, and it is, in turn, bordered by still later and lower-lying formations. The Bowden formation is made up of various sorts of sedimentary rock.

The next succeeding formations are classed as Pliocene. They are composed of marl and limestone of marine origin (Manchioneal), and of slight thickness, and of gravels from the uplands. The gravels are in part estuarine, in part subaërial, and in part littoral. The Pliocene formations have relatively slight surface development, though considerable areas in the vicinity of Kingston are covered by them.

Among the Pleistocene formations are beds of reef rock, ten to forty feet in thickness. They range in elevation from sea level up to seventy feet. They lie on eroded land surfaces, and their relations are significant of the movements to which the land had been subject before their formation. Other Pleistocene formations consist of chalky marls at low levels near the coast. Here belongs especially the Falmouth formation which rarely occurs higher than fifteen feet above the sea. The Falmouth formation is nothing more than a series of unconsolidated sea muds, probably synchronous with the younger elevated coral reefs. Among the latest formations are the alluvial deposits in valleys about the shores. In Montego Bay there are low islands which owe their origin primarily to mangroves.

There are some igneous rocks on the island. The oldest are the bowlders of andesite in the Blue Mountain series. The source of this igneous matter is unknown. There are mid-Tertiary igneous rocks in the form of dikes, laccoliths, etc., composed of hornblende-diorite, and granite-porphyry. These intrusive rocks affect the Blue Mountain series, and extend upward into the White Limestone above, but are found only in the eastern third of the island. In a single locality on the north coast near the east end of the island there is eruptive amygdaloidal basalt. There is everywhere more or less metamorphism in association with the igneous rocks.

The topography and stratigraphy of the island suggest the following sequence of events :

1. The first event in the history of the island so far as now known is the igneous activity which furnished the material for the Blue Mountain series. This was probably in Cretaceous time. The oldest formation of the island is composed of the débris of this activity. The amount of the débris was great, indicating that the volcanic activity was extensive.

2. The degradation of the volcanic débris and the re-deposition of the material in the form of sedimentary formations (the Blue Mountain series) was the second great event in the history of the island. The formation is such as to show (*a*) that there was rapid erosion and deposition ; (*b*) that the land from which the sediments came was high ; and (*c*) that the deposition was accomplished in shallow water.

3. The next event was the elevation, and, perhaps, the folding, of the beds of the Blue Mountain series. The folding probably followed the deposition of the Richmond (Eocene) formation ; that is, was mid-Eocene. On this point, however, the author is not altogether satisfied, and indicates that the folding may possibly have occurred later.

4. The next event was the sinking of the island, probably late in the Eocene period, followed by the deposition on the submerged surface of the great White Limestone formation. The subsidence is estimated to have been at least 1200 fathoms. This great subsidence submerged all but the higher parts of the Blue Mountain series, leaving at most only the parts which are now more than 3000 feet high out of water. The subsidence may have been even greater, submerging the whole island. The evidence of this great subsidence is found in the Montpelier chalk (the lower part of the White Limestone), the composition of which indicates, according to Mr. Hill, a depth of 1200 to 2300 fathoms. Further evidence of the great subsidence is found in the stratigraphically equivalent radiolarian earths in eastern Cuba—earths which call for depths of 3000 to 4000 fathoms. Mr. Hill thinks it would not be unfair to assume 10,000 feet as the mean subsidence of Jamaica (p. 165). The argument of Mr. Hill for so great a sinking does not seem altogether conclusive. If the whole of the island were submerged, and this would not seem to call for so great a subsidence (though still a great one) there is no apparent reason why formations due to pelagic life should not be made in shallow water, even though too deep for corals and other shore-life. A few hundred feet of water

would destroy these shallow water forms, and since there would be no source for terrigenous material, the shells of pelagic life should have been the chief source of sediment. The problem is the same as that presented by the Niobrara chalk of the United States. It shows absence of terrigenous sediment rather than great depth of water.

5. The next event in the history of Jamaica was the re-elevation of the island in the Oligocene period. The amount of elevation is estimated at 13,000 feet. If the preceding subsidence were less than stated above, the call for so great a rise would disappear. After this re-elevation, the island is believed to have had a much larger area than now. The uplift was accompanied by a gentle folding of the rock, the folding having an east-west axis, and therefore making an angle with the axes of the older mountains, the trend of which is northwest and southeast. With the general arching of this time there were many minor folds. It is believed to have been in connection with this elevation that the igneous intrusions of mid-Tertiary time were effected, and the higher terraces on the margins of the plateau developed.

6. The next event was another subsidence, contracting the island to the back coast border. The depression is placed at about 3000 feet. It was at this time (as well as during the preceding interval of emergence) that the back coast border of the plateau was developed. During this minor submergence the Bowden formation (Miocene), reaching up to levels of 300 feet, was deposited.

7. This subsidence was followed by an elevation. The Blue Mountain ridges and the plateau were elevated some 500 feet. The borders must have been elevated much more, for the southern coast is believed to have been extended out to about the present 500 fathom line. This movement of elevation was less orogenic in its character than any of the preceding, and was followed by a period of erosion. During the pre-Bowden epoch of erosion the streams did not get their heads far back into the plateau, but developed great amphitheaters near the edge of the back coast border, while great basins were being developed in the interior. During the post-Bowden interval of erosion, the coast streams worked back, and drained out many of these interior basins. It was during this elevation that the middle terraces, of the back coast border — those at elevations of 200 to 700 feet — were developed.

8. The next event was probably a late Pliocene subsidence of not more than 700 feet. This submerged the border of the island to the

base of the back coast border, covering the present low borders with littoral and estuarine formations.

9. The next and last event was an epeirogenic movement of upward phase, amounting to about 800 feet, which raised the submerged borders into the present coastal plain. This upward movement may have been interrupted by a minor subsidence, in early Pleistocene times.

There were, therefore, according to this interpretation four distinct periods of subsidence after the deposition of the Blue Mountian series. (*a*) The subsidence which preceded the deposition of the Montpelier (Oligocene) formation; (*b*) the subsidence which preceded the deposition of the Bowden (Miocene) formation; (*c*) the subsidence which prepared the way for the Manchioneal (Pliocene) formation, and (*d*) the subsidence which resulted in the deposition of the Pleistocene marine formations within the present land area. These four subsidences alternated with corresponding elevations: the first in the mid-Oligocene period, elevating the White Limestone; the second in the late Miocene, lifting the Bowden formation; the third in the early Pleistocene, bringing up the Pliocene formation; and the latest, exposing the marine Pleistocene. This series of uplifts and depressions constituted a diminishing series, being in this respect in consonance with other Antillean and with mid-American phenomena. The post-Richmond (early Eocene), the post-Moneague (mid-Oligocene, White Limestone), and post-Bowden (Miocene) uplifts were orogenic, diminishing, however, in their orogenicity.

In that part of the volume which deals with the relations of the Jamaican formations to those of adjacent regions, the author announces the general conclusion that the Jamaican sequence is very like that of the other islands of the Great Antilles.

In his summary of the history of the Antillean region the following generalizations are given:

1. The geology and configuration present no evidence whatsoever whereby past land connections can be established between these islands and the North and South American lands in Post-Jurassic time, especially in the Tertiary, Pleistocene, or recent epochs.

2. The configuration and condition of these islands in pre-Jurassic time cannot even be surmised.

3. There are some hypothetical and biologic reasons for believing that the outer rim of the American Mediterranean constituted a partial or complete bridge between the continents in Jurassic time, and that the Panama bridge did not then exist.

4. The first definite evidence of Antillean lands is found in the eruptive rocks of late Cretaceous time, when it is probable that there were marine volcanoes.

5. The land débris constituting the Eocene strata throughout the islands testifies the pre-existence of extensive Cretaceous land areas.

6. There was a profound regional subsidence in late Eocene and early Oligocene time, which submerged all but the highest tips of the Antilles, and which extended to the margins of the surrounding continents.

7. In late Oligocene or Miocene time there was a tremendous oroganic movement which resulted in uplift, whereby many of the islands were connected with each other, and possibly an insular southern portion of Florida, but not establishing land connection with the North and South American continents.

8. In Miocene or early Pliocene time the islands were severed by submergence into their present outlines and membership, which they have since retained with only secondary modification.

9. In Pliocene and Pleistocene time there have been intermittent periods of elevation without serious deformation, but not sufficient to establish land connections or to restore the islands to the heights and areas of mid-Tertiary time. The Pleistocene movements, while epeirogenic, were sufficiently differential to show that they were not uniform in all parts of the area, showing great differences in amplitude within the West Indian area, and were not harmonious with those of the North American coastal plain.

10. The irregularities of the submerged configuration of the West Indian region are orogenic, and not due to submerged continental drainage systems.

11. The elevated coral reefs of the West Indies were formed on rising lands.

In appendices Mr. Hill gives an additional note on the Geology of Porto Rico and Santiago de Cuba, and Mr. T. Wayland Vaughan describes some Cretaceous and Eocene corals from Jamaica. The note on the geology of Porto Rico and Santiago de Cuba, based on a recent geological reconnoissance, is as follows:

1. An older plexus of water-sorted hornblendic volcanic material—tuffs and conglomerates with interbedded Cretaceous Rudistean limestone similar to that of Jamaica, composing the central mountains.

2. An Eocene system of impure lignitic sands and clays like the Richmond beds, occurring on the western side of the island near San Sebastian.

3. Fossiliferous marl beds overlapping the above, which at this writing have not been determined.

4. Miocene coral limestone, unlike anything hitherto recorded from the Great Antilles, but of the type occurring in Antigua. These constitute the hilly country north and northwest of Lares.

5. White limestones of probable Pliocene age, composing the hills of the south coast.

6. Elevated reefs, but feebly represented.

7. Alluvial plains of Pleistocene age. The terrace phenomena are less developed upon this island than in any of the other Great Antilles, although the Pleistocene base leveling is well developed in stream valley phenomena. Dikes of syenitic-like porphyry, probably diorites, were also noted cutting the older hornblendic rocks.

Evidence was obtained indicating that the great mountain movement culminated before the Miocene, and that there has been at least one thousand feet of vertical uplift since that epoch.

The recent work in Cuba consists of a section across the Sierra Maestra from the coast to the Rio Cauto. In making the section, Mr. Hill was convinced "that the crystalline rocks of that region are Cretaceous and post-Eocene Tertiary, and not Paleozoic, as asserted by Frazer. . . ."

R. D. S.

Die Stillstandslagen des letzten Inlandeises und die hydrographische Entwickelung des pommerschen Küstengebietes. By Dr. K. Keilhack. Separatabdruck aus dem Jahrbuch der königl. preuss. geologischen Landesanstalt für 1898. Berlin. Pp. 90–152, 14 plates.

The immediate object of this paper is to set forth the relations between the edge of the ice and the drainage of north Germany during the last glacial epoch. The general slope of south Germany is northward, and the general slope of the ice which lay over north Germany was southward. Along the meeting of these opposing slopes, water courses were developed while the ice was in existence. Locally these marginal water courses were lakes, but often there was a river current along them. Many of the peculiarities of topography and drainage date from the time of ice occupancy.

Incidentally, several points of general interest are developed. Dr. Keilhack recognizes three distinct glacial epochs. During the last he recognizes five more or less distinct stages of the ice, one standing for the maximum advance of this epoch, and the others recessional stages. Each of these stages had its marginal water course.

During its maximum stage the limit of the ice in this epoch was just north of the Malapane and Oder rivers, as far west as the northward